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IV. *A new Method of finding Time by equal Altitudes.*
By Alexander Aubert, *Efq. F. R. S.*

R. Nov. 9, A MONG the various methods practifed for
1775.   finding time, that by equal altitudes of
the Sun or of a ftar, hath hitherto been efteemed the moft
eligible for obfervers who are not furnifhed with a good
and well-adjufted tranfit inftrument. But this method,
although one of the beft, is generally attended with in-
conveniencies, which render the practice of it more dif-
ficult, and the refult lefs perfect than one could wifh.

If the Sun or ftars near the equator are made ufe of,
as ufual, and the altitudes are taken near the prime ver-
tical, where the change of altitude is the quickeft, the in-
terval of time between the obfervations muft, in moft
latitudes, be of fo many hours, that the obferver cannot
always attend to the correfponding altitudes: the weather
may prove variable, fo as to difappoint him at laft; the
clock or watch may go irregularly during fo long an in-
terval; and if the altitudes cannot, on account of their
great diftance from the meridian, be taken very high;
an alteration in the ftate of the atmofphere may produce
a variation of the refraction, and occafion the horary
arcs to be different, although the apparent altitudes will
be the fame. To which may be added, the difficulty of
making

making the inftrument follow the object in its motion in azimuth, without danger of difturbing its adjuftment in regard to altitude.

To remedy all thefe inconveniencies, the following method was thought of; and having been practifed with conftant fuccefs, it is prefumed, the communication of it may be acceptable to aftronomers.
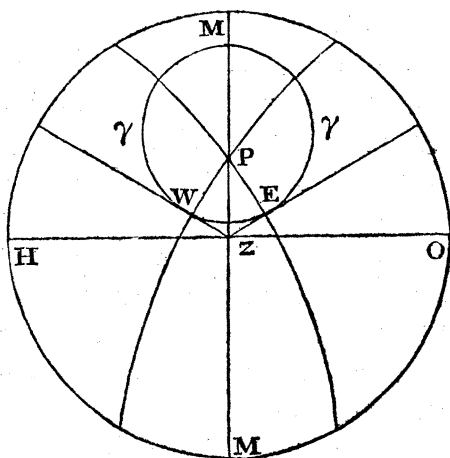
If a ftar is felected, of which the polar diftance is very little lefs than the complement of the latitude of the place of obfervation, it will, at equal diftances from the meridian, come to vertical circles, which touch its parallel of declination. The ftar, when in thefe ver-tical circles, will be near the meridian, near the prime vertical, and near the zenith; and confequently, if it be obferved there, the interval between the Eaftern and the Weftern altitudes will be fhort; the alteration in altitude will be quick; the ftar cannot be affected by a different refraction; befides, it will have no motion in azimuth.

To obferve the ftar in thefe vertical circles, two things are neceffary; the firft is, to be provided with an aftro-nomical quadrant, having three or more horizontal wires in the telefcope, and if it have alfo a *fpeculum* at the eye-end of the telefcope, to bring the vertical ray horizontal, it will be found very convenient.   The next thing is, to make a computation of the apparent zenith diftance of the ftar in the vertical circles which touch its parallel of declination; for if the telefcope be fixed to this zenith diftance, as foon as the ftar is

<div align="right">**found**</div>

found to come to it, it will be in the proper vertical circle.

The true zenith diftance is found eafily in the following manner; and if diminifhed by the refraction belonging to it, it will give the apparent zenith diftance wanted.

Let HMOM reprefent the horizon; Z the zenith; MM the meridian; P the pole of the equator; $\gamma\gamma$ the parallel of declination of a ftar, interfecting the meridian very near the zenith between Z and P. Then, the vertical circles ZE on the Eaftern fide of the meridian, and ZW on the Weftern fide, being drawn to touch the path of the ftar, the hour circles paffing through the points of contact E, W, will be at right angles to the circles of azimuth ZE, ZW.

Now in the right-angled fpheric triangle PEZ; PZ the complement of the latitude, and PE the ftar's polar diftance, being known, the other parts are eafily found; *viz.* ZE the zenith diftance, PZE the azimuth, ZPE the horary angle. So that the telefcope may be fixed properly, the pofition of the inftrument is afcertained, and the time known when the ftar may be expected in the field

field of the telefcope; and if the vertical wire is once brought near to the ftar, the ftar will appear to move parallel to it, and will pafs fucceffively over the horizontal wires, while the inftrument remains undifturbed.

The advantage of this method will appear in the following example of equal altitudes, taken the 15th July, 1773, at Loam-pit Hill, near Deptford, in latitude 51° 28′ 7″ N. and longitude 5″ in time W. of the Royal Obfervatory at Greenwich.

The ftar felected was γ Draconis, having 38° 28′ 21″ apparent North polar diftance, being very little lefs than the complement of the latitude 38° 31′ 53″.

Then cof. PE : rad. :: cof. PZ : cof. ZE = 2° 19′ the zenith diftance,
and fin. PZ : rad. :: fin. PE : fin. PZE = 87° 5′ 20″ the azimuth,

alfo rad. : tan. PE :: cotan. PZ : cof. ZPE = 3° 43′ 13″ the horary arc = 14′ 52,9″

in fidereal time, or 14′ 50,5″ in mean time.

The true zenith diftance being 2° 19′, the fame was diminifhed by 2″ for refraction, and the telefcope fixed to 2° 18′ 58″, the apparent zenith diftance; and when the ftar came to the wires, the times by the clock were as follow:

	Eaftern altitudes.				Weftern altitudes.		Meridian paffage.	
	h ′ ″				h ′ ″		h ′ ″	
1ft wire at	9 55 43	2′ 14″	2′ 14″		10 29 46		10 12 44,5	
2d	9 57 57	2 12	2 12		10 27 32		10 12 44,5	
3d	10 0 9				10 25 20		10 12 44,5	

fo that in about 34′ the compleat fet of altitudes was obtained near the prime vertical, free from the effects of a different refraction, and any motion in azimuth.   The

horary

horary arc obferved by the middle wire not turning out exactly according to the computation, is of no confequence to the obfervations. Some little difference may arife in it from fmall inaccuracies in the eftimation of the ftar's apparent polar diftance, the latitude of the place, or the error of the line of collimation; or from not fetting the telefcope exactly to the proper zenith diftance; but as the chief intention of the computation is to find the vertical circles in which the ftar hath no motion in azimuth, the other parts of it need not be ftrictly attended to.

The following manner of inferring mean time from the ftar's meridian paffage being more convenient and concife than the ufual one, may alfo be acceptable.

From the ftar's apparent right afcenfion, increafed by 24 hours if neceffary, fubtract the Sun's apparent right afcenfion for apparent noon; diminifh the remainder by the proportional part of the ftar's acceleration, at the rate of 3′ 55″,91 for 24 hours, of which a table is eafily computed; to this laft remainder apply the equation of time for apparent noon, according as it is additive or fubtractive; the refult will be the mean time of the ftar's paffing the meridian.

E X A M P L E.

E X A M P L E.

	h	′	″
The apparent Æ of γ Draconis the 15th July, 1773, was	17	51	24,0
— the apparent Æ of the Sun at apparent noon,	7	39	59,0
First remainder,	10	11	25,0
— the star's acceleration for 10 11 25, at 3 55,91 for 24 hours		1	40,2
Second Remainder,	10	9	44,8
+ the equation of time at apparent noon, additive,		5	27,7
Star's meridian passage in mean time,	10	15	12,5

But the clock shewed 10^h 12′ 44″,5 when the star passed, consequently it was 2′ 28″,0 too slow for mean time.

Observers, who are not furnished with tables of the Sun's right ascension and of the equation of time for the apparent noon of their meridian, may apply both as they are given in the Nautical Ephemeris for the meridian of the Royal Observatory at Greenwich; the result will be the mean time of the star's passing the Greenwich meridian. And by applying the proportional part of the foregoing acceleration of 3′ 55″,91, belonging to the difference of longitude in time of the place of observation from Greenwich, the mean time of the star's passing the meridian of the place of observation will be found. If the place be to the East of Greenwich, the acceleration will be additive; if to the West, subtractive.

In a fimilar manner, the mean time of any obfervation made with a clock, regulated to fidereal time, may be inferred, provided the preceding tranfit of the Sun hath been obferved; for if from the time of the obfervation by the clock, increafed, if neceffary, by 24 hours, the time of the obferved tranfit of the Sun be fubtracted, the remainder, diminifhed by the proportional part of 3′ 55″,91 and duly corrected by the equation of time for the preceding noon, will give the mean time required. It is underftood, that the clock keeps the rate of fidereal time exactly; for if not, a further correction for the lofs or gain fince noon muft be applied.